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(54) **MULTILAYER STRUCTURE**

(57) A multilayer structure comprising two or more layers including at least a layer (a) comprising (A) an aliphatic polyamide and a layer (b) comprising (B) a semi-aromatic polyamide comprising a diamine unit containing an aliphatic diamine unit having a carbon number of 9 to 13 in an amount of 60 mol% or more based on all diamine units and a dicarboxylic acid unit containing a terephthalic acid and/or naphthalenedicarboxylic acid unit in an

amount of 50 mol% or more based on all dicarboxylic acid units, with the layer (b) being disposed as the innermost layer. The multilayer structure of the present invention is excellent in the heat resistance, chemical resistance, liquid and/or gas chemical permeation-preventing property, monomer-oligomer elution resistance, interlayer adhesion and durability.

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## Description

## TECHNICAL FIELD

5 [0001] The present invention relates to a multilayer structure comprising a layer comprising an aliphatic polyamide and a layer comprising a semi-aromatic polyamide having a specific structure. More specifically, the present invention relates to a multilayer structure excellent in heat resistance, chemical resistance, liquid and/or gas chemical permeation-preventing properties, monomer-oligomer elution resistance, interlayer adhesion and durability.

## 10 BACKGROUND ART

[0002] In the field of automobile-related fuel tubes, hoses, tanks and the like, the main material for structural parts of an automobile is changing from metal to resin for reasons of the rusting due to anti-freezing agents on roads or proceeding of weight-saving of these parts in view of the recent issue of energy saving. For example, a saturated polyester-based resin, a polyolefin-based resin, a polyamide-based resin and a thermoplastic polyurethane-based resin are used. However, a single-layer hose using such a resin is insufficient in heat resistance, chemical resistance and the like and, therefore, is limited in its applicable range.

15 [0003] Furthermore, from the standpoint of preventing environmental pollution, strict regulations regarding exhaust gases have been recently implemented, including preventing volatile fuel hydrocarbons or the like from leaking out into air by diffusion through a fuel tube, a hose or a tank wall. The regulations will become more and more strict in the future and it is desired to maximally prevent fuel from permeating and evaporating through a fuel tube, a hose or a tank wall. Also, in the light of reducing gasoline consumption and attaining higher performance, an oxygen-containing gasoline having blended therein alcohols having a low boiling point, such as methanol and ethanol, or ethers such as methyl-tert-butyl ether (MTBE), is being used. However, permeation of this fuel cannot be satisfactorily prevented in a shaped article using a conventional polyamide-based resin alone and, particularly, only nylon 11 or nylon 12 excellent in strength, toughness, chemical resistance and flexibility. Thus, an improvement is particularly required in the prevention of alcohol-containing gasoline permeation.

25 [0004] In order to more successfully prevent the permeation of alcohol-containing gasoline, the wall thickness must be increased, but this incurs a problem that the piping tube decreases in flexibility or becomes heavy and furthermore, the material or production cost increases.

30 [0005] As a method for solving this problem, there has been proposed a multilayer structure having disposed therein a resin having good alcohol-containing gasoline permeation-preventing property, such as ethylene-vinyl acetate copolymer saponified product (EVOH), polymetaxylylene adipamide (nylon MXD6), polybutylene terephthalate (PBT), polyethylene naphthalate (PEN), polybutylene naphthalate (PBN), polyvinylidene fluoride (PVDF), ethylene/tetrafluoroethylene copolymer (ETFE), ethylene/chlorotrifluoroethylene copolymer (ECTFE), tetrafluoroethylene/hexafluoropropylene copolymer (TFE/HFP, FEP) and tetrafluoroethylene/hexafluoropropylene/vinylidene fluoride copolymer (TFE/HFP/VDF, THV) (see, for example, Kohyo (National Publication of Translated Version) No. 7-507739).

35 [0006] The ethylene-vinyl acetate copolymer saponified product (EVOH), polymetaxylylene adipamide (nylon MXD6) and the like are known to have good adhesion to nylon 6, but the adhesion to nylon 11 or nylon 12, which have been conventionally used in single-layer shaped articles, is insufficient and it is necessary to provide an adhesive layer between the layers or apply a specific surface treatment to the layers.

40 [0007] Other polyester-base resins and fluorine-based resins are low in the adhesion to a polyamide resin, and there has been proposed, for example, a technique of using an adhesive resin composition comprising a mixture of resins for the two layers to be bonded, such as a mixture of polyester-based or fluorine-based resin and polyamide resin. However, the adhesion is affected by the morphology of the adhesive resin composition mixture and this gives rise to a problem that the adhesion is greatly dispersed or decreased depending on the extrusion conditions, the environmental conditions on use, or the like.

45 [0008] As for the adhesive resin, a maleic anhydride-modified polyolefin resin and the like are known, but such a resin is lower in thermal aging resistance than polyamide resin and cannot be used in severe conditions, or the increase in the number of layers disadvantageously incurs a problem of complication in view of cost and process control.

50 [0009] Furthermore, it is known that when a shaped article using as an innermost layer, a conventionally employed polyamide-based resin, particularly, nylon 11 or nylon 12 excellent in the strength, toughness, chemical resistance and flexibility, comes into contact with the above-described fuel, low molecular components such as monomers and oligomers gradually dissolve out or precipitate into the fuel. These components may adhere to a movable part of an injector or a fuel tank valve and, as a result, an engine starting failure may occur or a problem may arise in view of the control of internal pressure of the fuel tank.

55 [0010] An object of the present invention is to solve these problems and provide a multilayer structure excellent in heat resistance, chemical resistance, liquid and/or gas chemical permeation-preventing properties, monomer-oligomer

elution resistance, interlayer adhesion and durability.

## SUMMARY OF THE INVENTION

[0011] As a result of intensive studies to solve the problems, the present inventors have found that a multilayer structure comprising a layer comprising an aliphatic polyamide and a layer comprising a semi-aromatic polyamide having a specific structure, in which the layer comprising a semi-aromatic polyamide having a specific structure is disposed as the innermost layer, is excellent in interlayer adhesion, liquid and/or gas chemical permeation-preventing properties and monomer-oligomer elution resistance and satisfies various properties such as heat resistance and chemical resistance.

[0012] More specifically, the present invention relates to the following.

(1) A multilayer structure comprising two or more layers including at least a layer (a) comprising (A) an aliphatic polyamide and a layer (b) comprising (B) a semi-aromatic polyamide comprising a diamine unit containing an aliphatic diamine unit having a carbon number of 9 to 13 in an amount of 60 mol% or more based on all diamine units and a dicarboxylic acid unit containing a terephthalic acid and/or naphthalenedicarboxylic acid unit in an amount of 50 mol% or more based on all dicarboxylic acid units, with said layer (b) being disposed as the innermost layer.

(2) The multilayer structure as described in (1) above, wherein the multilayer structure comprises a two-layer construction of (a)/(b).

(3) The multilayer structure as described in (1) or (2) above, wherein the (A) aliphatic polyamide is at least one homopolymer selected from the group consisting of polycaproamide (polyamide 6), polyhexamethylenedipamide (polyamide 66), polyhexamethylenedodecamide (polyamide 612), polyundecanamide (polyamide 11) and polydodecanamide (polyamide 12), or a copolymer using a plurality of species of raw material monomers forming these polyamides.

(4) The multilayer structure as described in any one of (1) to (3) above, wherein the (B) semi-aromatic polyamide is a polyamide comprising a diamine unit containing a 1,9-nonanediamine and/or 2-methyl-1,8-octanediamine unit in an amount of 60 mol% or more based on all diamine units and a dicarboxylic acid unit containing a terephthalic acid unit in an amount of 50 mol% or more based on all dicarboxylic acid units.

(5) The multilayer structure as described in any one of (1) to (3) above, wherein the (B) semi-aromatic polyamide is a polyamide comprising a diamine unit containing a 1,9-nonanediamine and/or 2-methyl-1,8-octanediamine unit in an amount of 60 mol% or more based on all diamine units and a dicarboxylic acid unit containing a naphthalenedicarboxylic acid unit in an amount of 50 mol% or more based on all dicarboxylic acid units.

(6) The multilayer structure as described in any one of (1) to (5) above, wherein the layer (b) has electrical conductivity.

(7) The multilayer structure as described in any one of (1) to (6) above, wherein the layers are formed by coextrusion.

(8) A multilayer structure selected from the group consisting of a film, a hose, a tube, a bottle and a tank, comprising the multilayer structure described in any one of (1) to (7) above.

(9) The multilayer structure as described in (8) above, which is an automotive fuel piping tube or hose.

(10) The multilayer structure as described in any one of (1) to (9) above, wherein the layer (a) and the layer (b) are adjacently disposed.

[0013] The multilayer structure of the present invention is excellent in heat resistance, chemical resistance, liquid and/or gas chemical permeation-preventing properties, monomer-oligomer elution resistance, interlayer adhesion and durability. Accordingly, the multilayer structure of the present invention is effective as a film, a hose, a tube, a bottle or a tank for use in automobile parts, industrial materials, industrial supplies, electrical and electronic parts, machine parts, office equipment parts, household articles and containers. The multilayer structure of the present invention is particularly useful as an automotive fuel piping tube or hose.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Figs. 1 and 2 each is a cross-sectional view of the multilayer structure of the present invention.

## BEST MODE FOR CARRYING OUT THE INVENTION

[0015] The present invention is described in detail below.

[0016] The (A) aliphatic polyamide for use in the present invention contains an amide bond (-NHCO-) in the main chain and comprises an aliphatic polyamide-forming unit. The (A) aliphatic polyamide can be obtained by using, as the raw material, a lactam, an aminocarboxylic acid or a nylon salt comprising an aliphatic diamine and an aliphatic dicarboxylic

acid, and polymerizing or copolymerizing it by a known method such as melt polymerization, solution polymerization or solid phase polymerization.

[0017] Examples of the lactam include  $\epsilon$ -caprolactam, enantholactam, undecanelactam, dodecanelactam,  $\alpha$ -pyrrolidone and  $\alpha$ -piperidone. Examples of the aminocarboxylic acid include 6-aminocaproic acid, 7-aminoheptanoic acid, 9-aminononanoic acid, 11-aminoundecanoic acid and 12-aminododecanoic acid. One species or two or more species thereof may be used.

[0018] Examples of the aliphatic diamine constituting the nylon salt include ethylenediamine, 1,3-propylenediamine, 1,4-butanediamine, 1,5-pentanediamine, 1,6-hexanediamine, 1,7-heptanediamine, 1,8-octanediamine, 1,9-nonanediamine, 1,10-decanediamine, 1,11-undecanediamine, 1,12-dodecanediamine, 1,13-tridecanediamine, 1,14-tetradecanediamine, 1,15-pentadecanediamine, 1,16-hexadecanediamine, 1,17-heptadecanediamine, 1,18-octadecanediamine, 1,19-nonadecanediamine, 1,20-eicosanediamine, 2/3-methyl-1,5-pentanediamine, 2-methyl-1,8-octanediamine, 2,2,4/2,4,4-trimethyl-1,6-hexanediamine and 5-methyl-1,9-nonanediamine. One species or two or more species thereof may be used.

[0019] Examples of the aliphatic dicarboxylic acid constituting the nylon salt include adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, undecanedicarboxylic acid, dodecanedicarboxylic acid, tridecanedicarboxylic acid, tetradecanedicarboxylic acid, pentadecanedicarboxylic acid, hexadecanedicarboxylic acid, octadecanedicarboxylic acid and eicosanedicarboxylic acid. One species or two or more species thereof may be used.

[0020] Examples of the (A) aliphatic polyamide for use in the present invention include a homopolymer such as polycaproamide (polyamide 6), polyundecanamide (polyamide 11), polydodecanamide (polyamide 12), polyethyleneadipamide (polyamide 26), polytetramethylene adipamide (polyamide 46), polyhexamethylene adipamide (polyamide 66), polyhexamethylene azelamide (polyamide 69), polyhexamethylene sebacamide (polyamide 610), polyhexamethylene undecamide (polyamide 611), polyhexamethylene dodecamide (polyamide 612), polynonamethylene adipamide (polyamide 96), polynonamethylene azelamide (polyamide 99), polynonamethylene sebacamide (polyamide 910), polynonamethylene undecamide (polyamide 911), polynonamethylene dodecamide (polyamide 912), polydecamethylene adipamide (polyamide 106), polydecamethylene azelamide (polyamide 109), polydecamethylene sebacamide (polyamide 1010), polydecamethylene dodecamide (polyamide 1012), polydodecamethylene adipamide (polyamide 126), polydodecamethylene azelamide (polyamide 129), polydodecamethylene sebacamide (polyamide 1210) and polydodecamethylene dodecamide (polyamide 1212), and a copolymer using a plurality of species of raw material monomers forming these polyamides.

[0021] Among these, preferred are at least one homopolymer selected from the group consisting of polycaproamide (polyamide 6), polyhexamethylene adipamide (polyamide 66), polyundecanamide (polyamide 11), polydodecanamide (polyamide 12) and polyhexamethylene dodecamide (polyamide 612), and a copolymer using a plurality of species of raw material monomers forming these polyamides. In view of heat resistance and cost, homopolymers of polycaproamide (polyamide 6) and polyhexamethylene adipamide (polyamide 66) are more preferred, and in view of resistance against hot water, zinc chloride and calcium chloride, homopolymers of polyundecanamide (polyamide 11), polydodecanamide (polyamide 12) and polyhexamethylene dodecamide (polyamide 612) are more preferred.

[0022] The (A) aliphatic polyamide for use in the present invention may be a mixture of those homopolymers, a mixture of those copolymers, or a mixture of the homopolymer and the copolymer, or may also be a mixture with other polyamide-based resin or other thermoplastic resin. In the mixture, the content of the (A) aliphatic polyamide is preferably 60 wt% or more, more preferably 80 wt% or more.

[0023] Examples of the other polyamide-based resin include polymetaxylene adipamide (polyamide MXD6), polymetaxylene suberamide (polyamide MXD8), polymetaxylene azelamide (polyamide MXD9), polymetaxylene sebacamide (polyamide MXD10), polymetaxylene dodecamide (polyamide MXD12), polymetaxylene terephthalamide (polyamide MXDT), polymetaxylene isophthalamide (polyamide MXDI), polymetaxylene naphthalamide (polyamide MXDN), polybis(4-aminocyclohexyl)methane dodecamide (polyamide PACM12), polybis(4-aminocyclohexyl)methane terephthalamide (polyamide PACMT), polybis(4-aminocyclohexyl)methane isophthalamide (polyamide PACMI), polybis(3-methyl-4-aminocyclohexyl)methane dodecamide (polyamide dimethyl PACM12), polyisophorone adipamide (polyamide IPD6), polyisophorone terephthalamide (polyamide IPDT), polyhexamethylene terephthalamide (polyamide 6T), polyhexamethylene isophthalamide (polyamide 6I), polynonamethylene isophthalamide (polyamide 9I), polynonamethylene hexahydroterephthalamide (polyamide 9T(H)), polydecamethylene isophthalamide (polyamide 10I), polydecamethylene hexahydroterephthalamide (polyamide 10T(H)), polyundecamethylene isophthalamide (polyamide 11I), polyundecamethylene hexahydroterephthalamide (polyamide 11T(H)), polydodecamethylene isophthalamide (polyamide 12I), polydodecamethylene hexahydroterephthalamide (polyamide 12T(H)), and a copolymer using a plurality of species of raw material monomers of these polyamides and/or raw material monomers of the above-described aliphatic polyamides. One species or two or more species thereof may be used.

[0024] Examples of the other thermoplastic resin include a polyolefin-based resin such as high-density polyethylene (HDPE), medium-density polyethylene (MDPE), low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), ultrahigh molecular weight polyethylene (UHMWPE), polypropylene (PP), ethylene/propylene copolymer

(EPR), ethylene/butene copolymer (EBR), ethylene/vinyl acetate copolymer (EVA), ethylene/vinyl acetate copolymer saponified product (EVOH), ethylene/acrylic acid copolymer (EAA), ethylene/methacrylic acid copolymer (EMAA), ethylene/methyl acrylate copolymer (EMA), ethylene/methyl methacrylate copolymer (EMMA) and ethylene/ethyl acrylate copolymer (EEA); the above-described polyolefin-based resin where a functional group such as carboxyl group or its salt, acid anhydride group and epoxy group is incorporated; a polyester-based resin such as polybutylene terephthalate (PBT), polyethylene terephthalate (PET), polyethylene isophthalate (PEI), PET/PEI copolymer, polyarylate (PAR), polyethylene naphthalate (PEN), polybutylene naphthalate (PBN) and liquid crystal polyester (LCP); a polyether-based resin such as polyacetal (POM) and polyphenylene oxide (PPO); a polysulfone-based resin such as polysulfone (PSF) and polyether sulfone (PES); a polythioether-based resin such as polyphenylene sulfide (PPS) and polythioethersulfone (PTES); a polyketone-based resin such as polyether ether ketone (PEEK) and polyallyl ether ketone (PAEK); a polynitrile-based resin such as polyacrylonitrile (PAN), polymethacrylonitrile, acrylonitrile/styrene copolymer (AS), methacrylonitrile/styrene copolymer, acrylonitrile/butadiene/styrene copolymer (ABS) and methacrylonitrile/styrene/butadiene copolymer (MBS); a polymethacrylate-based resin such as polymethyl methacrylate (PMMA) and polyethyl methacrylate (PEMA); a polyvinyl-based resin such as polyvinyl alcohol (PVA), polyvinylidene chloride (PVDC), polyvinyl chloride (PVC), vinyl chloride/vinylidene chloride copolymer and vinylidene chloride/methyl acrylate copolymer; a cellulose-based resin such as cellulose acetate and cellulose butyrate; a fluorine-based resin such as polyvinylidene fluoride (PVDF), polyvinyl fluoride (PVF), polychlorofluoroethylene (PCTFE), tetrafluoroethylene/ethylene copolymer (ETFE), ethylene/chlorotrifluoroethylene copolymer (ECTFE), tetrafluoroethylene/hexafluoropropylene copolymer (TFE/HFP, FEP), tetrafluoroethylene/hexafluoropropylene/vinylidene fluoride copolymer (TFE/HFP/VDF, THV) and tetrafluoroethylene/fluoro(alkyl)vinylether copolymer (PFA); a polycarbonate-based resin such as polycarbonate (PC); a polyimide-based resin such as thermoplastic polyimide (PI), polyamideimide (PAI) and polyether imide; and a thermoplastic polyurethane-based resin. One species or two or more species thereof may be used.

[0025] In the (A) aliphatic polyamide for use in the present invention, a plasticizer is preferably added. Examples of the plasticizer include benzenesulfonic acid alkylamides, toluenesulfonic acid alkylamides and hydroxybenzoic acid alkyl esters.

[0026] Examples of the benzenesulfonic acid alkylamides include benzenesulfonic acid propylamide, benzenesulfonic acid butylamide and benzenesulfonic acid 2-ethylhexylamide.

[0027] Examples of the toluenesulfonic acid alkylamides include N-ethyl-o- or N-ethyl-p-toluenesulfonic acid butylamide and N-ethyl-o- or N-ethyl-p-toluenesulfonic acid 2-ethylhexylamide.

[0028] Examples of the hydroxybenzoic acid alkyl esters include ethylhexyl o- or p-hydroxybenzoate, hexyldecyl o- or p-hydroxybenzoate, ethyldecyl o- or p-hydroxybenzoate, octyldecyl o- or p-hydroxybenzoate, decyldecyl o- or p-hydroxybenzoate, methyl o- or p-hydroxybenzoate, butyl o- or p-hydroxybenzoate, hexyl o- or p-hydroxybenzoate, n-octyl o- or p-hydroxybenzoate, decyl o- or p-hydroxybenzoate, and dodecyl o- or p-hydroxybenzoate.

[0029] Among these, preferred are benzenesulfonic acid alkylamides such as benzenesulfonic acid butylamide and benzenesulfonic acid 2-ethylhexylamide, toluenesulfonic acid alkylamides such as N-ethyl-p-toluenesulfonic acid butylamide and N-ethyl-p-toluenesulfonic acid 2-ethylhexylamide, and hydroxybenzoic acid alkyl esters such as ethylhexyl p-hydroxybenzoate, hexyldecyl p-hydroxybenzoate and ethyldecyl p-hydroxybenzoate, more preferred are benzenesulfonic acid butylamide, ethylhexyl p-hydroxybenzoate and hexyldecyl p-hydroxybenzoate.

[0030] The amount of the plasticizer blended is preferably from 1 to 30 parts by weight, more preferably from 1 to 15 parts by weight, per 100 parts by weight of the (A) aliphatic polyamide component. If the amount of the plasticizer blended exceeds 30 parts by weight, the multilayer structure (for example, an automotive fuel piping tube or hose) may disadvantageously lose its low-temperature impact resistance.

[0031] In the (A) aliphatic polyamide for use in the present invention, an impact resistance improver is preferably added. The impact resistance improver includes a rubber-like polymer, and a polymer having a flexural modulus of 500 MPa or less as measured according to ASTM D-790 is preferred. If the flexural modulus is higher than this value, the polymer is sometimes improper as the impact resistance improver.

[0032] Examples of the impact resistance improver include an (ethylene and/or propylene)/ $\alpha$ -olefin-based copolymer, an (ethylene and/or propylene)/( $\alpha,\beta$ -unsaturated carboxylic acid and/or unsaturated carboxylic acid ester)-based copolymer, an ionomeric polymer and an aromatic vinyl compound/conjugated diene compound-based block copolymer. One species or two or more species thereof may be used.

[0033] The (ethylene and/or propylene)/ $\alpha$ -olefin-based copolymer is a polymer obtained by copolymerizing an ethylene and/or propylene with an  $\alpha$ -olefin having a carbon number of 3 or more. Examples of the  $\alpha$ -olefin having a carbon number of 3 or more include propylene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, 1-undecene, 1-dodecene, 1-tridecene, 1-tetradecene, 1-pentadecene, 1-hexadecene, 1-heptadecene, 1-octadecene, 1-nonadecene, 1-eicosene, 3-methyl-1-butene, 3-methyl-1-pentene, 3-ethyl-1-pentene, 4-methyl-1-pentene, 4-methyl-1-hexene, 4,4-dimethyl-1-hexene, 4,4-dimethyl-1-pentene, 4-ethyl-1-hexene, 3-ethyl-1-hexene, 9-methyl-1-decene, 11-methyl-1-dodecene and 12-ethyl-1-tetradecene. One species or two or more species thereof may be used.

[0034] Also, a polyene of a non-conjugated diene such as 1,4-pentadiene, 1,4-hexadiene, 1,5-hexadiene, 1,4-octa-

diene, 1,5-octadiene, 1,6-octadiene, 1,7-octadiene, 2-methyl-1,5-hexadiene, 6-methyl-1,5-heptadiene, 7-methyl-1,6-octadiene, 4-ethylidene-8-methyl-1,7-nonadiene, 4,8-dimethyl-1,4,8-decatriene (DMDT), dicyclopentadiene, cyclohexadiene, cyclooctadiene, 5-vinylbornene, 5-ethylidene-2-norbornene, 5-methylene-2-norbornene, 5-isopropylidene-2-norbornene, 6-chloromethyl-5-isopropenyl-2-norbornene, 2,3-diisopropylidene-5-norbornene, 2-ethylidene-3-isopropylidene-5-norbornene and 2-propenyl-2,5-norbornadiene, may be copolymerized. One species or two or more species thereof may be used.

**[0035]** The (ethylene and/or propylene)/( $\alpha,\beta$ -unsaturated carboxylic acid and/or unsaturated carboxylic acid ester)-based copolymer is a polymer obtained by copolymerizing an ethylene and/or propylene with an  $\alpha,\beta$ -unsaturated carboxylic acid and/or unsaturated carboxylic acid ester monomer. Examples of the  $\alpha,\beta$ -unsaturated carboxylic acid monomer include an acrylic acid and a methacrylic acid, and examples of the  $\alpha,\beta$ -unsaturated carboxylic acid ester monomer include a methyl ester, an ethyl ester, a propyl ester, a butyl ester, a pentyl ester, a hexyl ester, a heptyl ester, an octyl ester, a nonyl ester and a decyl ester of those unsaturated carboxylic acids. One species or two or more species thereof may be used.

**[0036]** The ionic polymer is a copolymer of an olefin and an  $\alpha,\beta$ -unsaturated carboxylic acid, where at least a part of the carboxyl group is ionized by the neutralization of a metal ion. The olefin is preferably an ethylene and the  $\alpha,\beta$ -unsaturated carboxylic acid is preferably an acrylic acid or a methacrylic acid. However, the ionic polymer is not limited thereto and an unsaturated carboxylic acid ester monomer may be copolymerized. Examples of the metal ion include an alkali metal and an alkaline earth metal, such as Li, Na, K, Mg, Ca, Sr and Ba, and ions such as Al, Sn, Sb, Ti, Mn, Fe, Ni, Cu, Zn and Cd. One species or two or more species thereof may be used.

**[0037]** The aromatic vinyl compound/conjugated diene compound-based block copolymer is a block copolymer comprising an aromatic vinyl compound-based polymer block and a conjugated diene-based polymer block. A block copolymer having at least one aromatic vinyl compound-based polymer block and at least one conjugated diene-based polymer block is used. In this block copolymer, an unsaturated bond in the conjugated diene-based polymer block may be hydrogenated.

**[0038]** The aromatic vinyl compound-based polymer block is a polymer block mainly comprising a structural unit derived from an aromatic vinyl compound. Examples of the aromatic vinyl compound include styrene,  $\alpha$ -methylstyrene, o-methylstyrene, m-methylstyrene, p-methylstyrene, 2,4-dimethylstyrene, vinylanthracene, vinylanthracene, 4-propylstyrene, 4-cyclohexylstyrene, 4-dodecylstyrene, 2-ethyl-4-benzylstyrene and 4-(phenylbutyl)styrene. One species or two or more species thereof may be used. Depending on the case, the aromatic vinyl compound-based polymer block may have a structural unit comprising a slight amount of other unsaturated monomer. The conjugated diene-based polymer block is a polymer block formed from one species or two or more species of conjugated diene compounds such as 1,3-butadiene, chloroprene, isoprene, 2,3-dimethyl-1,3-butadiene, 1,3-pentadiene, 4-methyl-1,3-pentadiene and 1,3-hexadiene. In the hydrogenated aromatic vinyl compound/conjugated diene compound-based block copolymer, the unsaturated bond moiety in the conjugated diene-based polymer block is partially or entirely hydrogenated to form a saturated bond.

**[0039]** The molecular structure of the aromatic vinyl compound/conjugated diene compound-based block copolymer or a hydrogenated product thereof may be linear, branched or radial or may be an arbitrary combination thereof. Among these aromatic vinyl compound/conjugated diene compound-based block copolymers and/or a hydrogenated product thereof, preferred are one species or two or more species of a diblock copolymer where one aromatic vinyl compound-based polymer block and one conjugated diene-based polymer block are linearly bonded, a triblock copolymer where three polymer blocks are linearly bonded in the order of aromatic vinyl compound-based polymer block-conjugated diene-based polymer block-aromatic vinyl compound-based polymer block, and a hydrogenated product thereof. Examples thereof include an unhydrogenated or hydrogenated styrene/butadiene block copolymer, an unhydrogenated or hydrogenated styrene/isoprene block copolymer, an unhydrogenated or hydrogenated styrene/isoprene/styrene block copolymer, an unhydrogenated or hydrogenated styrene/butadiene/styrene block copolymer, and an unhydrogenated or hydrogenated styrene/isoprene/butadiene/styrene block copolymer.

**[0040]** The (ethylene and/or propylene)/ $\alpha$ -olefin-based copolymer, (ethylene and/or propylene)/( $\alpha,\beta$ -unsaturated carboxylic acid and/or unsaturated carboxylic acid ester)-based copolymer, ionic polymer, and aromatic vinyl compound/conjugated diene compound-based block copolymer and the like, which are used as the impact resistance improver, are preferably a polymer modified with a carboxylic acid and/or a derivative thereof. By modification with such a component, a functional group having affinity for the polyamide resin is incorporated into the polymer molecule.

**[0041]** Examples of the functional group having affinity for the polyamide resin include a carboxylic acid group, an acid anhydride group, a carboxylic acid ester group, a carboxylic acid metal salt, a carboxylic acid imide group, a carboxylic acid amide group and an epoxy group. Examples of the compound containing such a functional group include an acrylic acid, a methacrylic acid, a maleic acid, a fumaric acid, an itaconic acid, a crotonic acid, a mesaconic acid, a citraconic acid, a glutaric acid, a cis-4-cyclohexene-1,2-dicarboxylic acid, an endo-bicyclo[2.2.1]-5-heptene-2,3-dicarboxylic acid, a metal salt of these carboxylic acids, a monomethyl maleate, a monomethyl itaconate, a methyl acrylate, an ethyl acrylate, a butyl acrylate, a 2-ethylhexyl acrylate, a hydroxyethyl acrylate, a methyl methacrylate, a 2-ethylhexyl

methacrylate, a hydroxyethyl methacrylate, an aminoethyl methacrylate, a dimethyl maleate, a dimethyl itaconate, a maleic anhydride, an itaconic anhydride, a citraconic anhydride, an endo-bicyclo-[2.2.1]-5-heptene-2,3-dicarboxylic anhydride, a maleimide, an N-ethylmaleimide, an N-butylmaleimide, an N-phenylmaleimide, an acrylamide, a methacrylamide, a glycidyl acrylate, a glycidyl methacrylate, a glycidyl ethacrylate, a glycidyl itaconate and a glycidyl citraconate.

One species or two or more species thereof may be used.

[0042] The amount of the impact resistance improver blended is preferably from 1 to 35 parts by weight, more preferably from 5 to 25 parts by weight, per 100 parts by weight of the (A) aliphatic polyamide component. If the amount of the impact resistance improver blended exceeds 35 parts by weight, the mechanical properties inherent to the multilayer structure may be impaired.

[0043] In the case where the (A) aliphatic polyamide for use in the present invention is a polyamide having a relatively small number of carbons per one amide group in the polyamide repeating unit, such as polyamide 6 or polyamide 66, a polyamide comprising an aliphatic diamine and a terephthalic acid and/or an isophthalic acid as the polyamide-forming units is preferably blended so as to enhance the calcium chloride resistance. As for the aliphatic diamine used here, 1,6-hexanediamine is preferably selected in view of compatibility with polyamide 6 or polyamide 66. A terephthalic acid and an isophthalic acid are used at an arbitrary ratio, but the ratio of terephthalic acid/isophthalic acid is preferably from 80/20 to 20/80 (by weight).

[0044] The polyamide comprising an aliphatic diamine and a terephthalic acid and/or an isophthalic acid as the polyamide-forming units may be a polymer where these polyamide-forming units occupy 100 wt%, or may be a copolymer comprising 85 wt% or more of said polyamide-forming units and 15 wt% or less of a polyamide-forming unit introduced from other components, for example, a lactam, an aminocarboxylic acid, a dicarboxylic acid except for a terephthalic acid and an isophthalic acid, and a diamine. As for the other copolymerization unit, a polyamide composed of a hexamethylene adipamide unit and/or a caproamide unit is particularly preferred.

[0045] In the (A) aliphatic polyamide, an antioxidant, a heat stabilizer, an ultraviolet absorber, a light stabilizer, a lubricant, an inorganic filler, an antistatic agent, a flame retardant, a crystallization accelerator, a coloring agent, a plasticizer and the like may be further added, if desired.

[0046] The production apparatus used for the production of the (A) aliphatic polyamide includes a known polyamide production apparatus such as batch-system reactor, one-bath or multi-bath continuous reaction apparatus, tubular continuous reaction apparatus and kneading reaction extruder (e.g., single-screw kneading extruder, twin-screw kneading extruder). The polymerization may be performed by using a known polymerization method such as melt polymerization, solution polymerization or solid phase polymerization, and repeating the operation under atmospheric pressure, reduced pressure or applied pressure. These polymerization methods may be used individually or in an appropriate combination.

[0047] The relative viscosity of the (A) aliphatic polyamide as measured according to JIS K-6920 is preferably from 1.5 to 5.0, more preferably from 2.0 to 4.5. If the relative viscosity of the (A) aliphatic polyamide is less than the above-described value, the obtained multilayer structure may have insufficient mechanical properties, whereas if it exceeds the above-described value, the extrusion pressure or torque becomes excessively high and this sometimes makes it difficult to produce a multilayer structure.

[0048] The (B) semi-aromatic polyamide for use in the present invention is a polyamide comprising a diamine unit containing an aliphatic diamine unit having a carbon number of 9 to 13 in an amount of 60 mol% or more based on all diamine units and a dicarboxylic acid unit containing a terephthalic acid and/or naphthalenedicarboxylic acid unit in an amount of 50 mol% or more based on all dicarboxylic acid units (hereinafter sometimes referred to as a "semi-aromatic polyamide").

[0049] In the (B) semi-aromatic polyamide, the content of the unit comprising a terephthalic acid and/or a naphthalenedicarboxylic acid is 50 mol% or more, preferably 60 mol% or more, more preferably 75 mol% or more, still more preferably 90 mol% or more, based on all dicarboxylic acid units. If the content of the terephthalic acid and/or naphthalenedicarboxylic acid unit is less than 50 mol%, the obtained multilayer structure tends to be deteriorated in various physical properties such as heat resistance, chemical resistance and liquid and/or gas chemical permeation-preventing properties.

[0050] Examples of the naphthalenedicarboxylic acid unit include units derived from a 2,6-naphthalenedicarboxylic acid, a 2,7-naphthalenedicarboxylic acid, a 1,4-naphthalenedicarboxylic acid and a 1,5-naphthalenedicarboxylic acid. One species or two or more species thereof may be used. Among these naphthalenedicarboxylic acid units, a unit derived from a 2,6-naphthalenedicarboxylic acid is preferred.

[0051] The dicarboxylic acid unit in the (B) semi-aromatic polyamide may contain other dicarboxylic acid unit except for the unit derived from a terephthalic acid and/or a naphthalenedicarboxylic acid and/or the like, within the range of not impairing various excellent properties of the multilayer structure of the present invention. Examples of the other dicarboxylic acid unit include units derived from an aliphatic dicarboxylic acid such as malonic acid, dimethylmalonic acid, succinic acid, glutaric acid, adipic acid, 2-methyladipic acid, 2,2,4/2,4,4-trimethyladipic acid, pimelic acid, 2,2-dimethylglutaric acid, 2,2-diethylsuccinic acid, suberic acid, azelaic acid, sebacic acid, undecanedicarboxylic acid and dodecanedicarboxylic acid; an alicyclic dicarboxylic acid such as 1,3-cyclopentanedicarboxylic acid and 1,3/1,4-cy-



clohexanedicarboxylic acid; and an aromatic dicarboxylic acid such as isophthalic acid, 1,3/1,4-phenylenedioxydiacetic acid, diphenic acid, 4,4'-oxydibenzoic acid, diphenylmethane-4,4'-dicarboxylic acid, diphenylethane-4,4'-dicarboxylic acid, diphenylpropane-4,4'-dicarboxylic acid, diphenylsulfone-4,4'-dicarboxylic acid and 4,4'-biphenyldicarboxylic acid. One species or two or more species thereof may be used. Among these units, a unit derived from an aromatic dicarboxylic acid is preferred. The content of the other dicarboxylic acid unit is 50 mol% or less, preferably 40 mol% or less, more preferably 25 mol% or less, still more preferably 10 mol% or less. In addition, a polyvalent carboxylic acid such as trimellitic acid, trimesic acid and pyromellitic acid may also be used within the range allowing for melt shaping.

**[0052]** In the (B) semi-aromatic polyamide, the content of the aliphatic diamine unit having a carbon number of 9 to 13 is 60 mol% or more, preferably 75 mol% or more, more preferably 90 mol% or more, based on all diamine units. If the content of the aliphatic diamine unit having a carbon number of 9 to 13 is less than 60 mol%, the multilayer structure tends to be deteriorated in the heat resistance, chemical resistance, and liquid and/or gas chemical permeation-preventing property and impact resistance.

**[0053]** The aliphatic diamine unit having a carbon number of 9 to 13 includes units derived from 1,9-nonanediamine, 1,10-decanediamine, 1,11-undecanediamine, 1,12-dodecanediamine and 1,13-tridecanediamine. As long as the above-described carbon number is satisfied, not only a linear aliphatic diamine unit but also a unit derived from a branched aliphatic diamine such as 2,2,4/2,4,4-trimethyl-1,6-hexanediamine, 2,4-diethyl-1,6-hexanediamine, 2,2/2,3/2,4/2,5-dimethyl-heptanediamine, 2/3/4-methyl-1,8-octanediamine, 1,3/1,4/2,2/2,4/3,3/3,4/4,4/4,5-dimethyl-1,8-octanediamine, 5-methyl-1,9-nonanediamine and 2/3-butyl-1,8-octanediamine, may be contained. One species or two or more species thereof may be used.

**[0054]** Among these aliphatic diamine units having a carbon number of 9 to 13, in view of liquid and/or gas chemical permeation-preventing property, units derived from 1,9-nonanediamine and/or 2-methyl-1,8-octanediamine are preferred. Furthermore, in view of balance among shapability, impact resistance and coextrusion formability, the molar ratio of the 1,9-nonanediamine unit and the 2-methyl-1,8-octanediamine unit is preferably from 30:70 to 98:2 mol%, more preferably from 40:60 to 95:5 mol%.

**[0055]** The diamine unit in the (B) semi-aromatic polyamide may contain other diamine units except for the unit derived from an aliphatic diamine having a carbon number of 9 to 13, within the range of not impairing various excellent properties of the multilayer structure of the present invention. Examples of the other diamine unit include units derived from an aliphatic diamine such as ethylenediamine, 1,3-propylenediamine, 1,4-butanediamine, 1,6-hexanediamine, 1,8-octanediamine, 3-methyl-1,5-pentanediamine; an alicyclic diamine such as 1,3/1,4-cyclohexanediamine, 1,3/1,4-cyclohexanedimethylamine, bis(4-aminocyclohexyl)methane, bis(4-aminocyclohexyl)propane, bis(3-methyl-4-aminocyclohexyl)methane, bis(3-methyl-4-aminocyclohexyl)propane, 5-amino-2,2,4-trimethyl-1-cyclopentanemethylamine, 5-amino-1,3,3-trimethylcyclohexanemethylamine, bis(aminopropyl)piperazine, bis(aminoethyl)piperazine, norbornanedimethylamine and tricyclodecanedimethylamine; and an aromatic diamine such as para-phenylenediamine, meta-phenylenediamine, para-xylylenediamine, meta-xylylenediamine, 1,4/1,5/2,6/2,7-naphthalenedimethylamine, 4,4'-diaminodiphenylmethane, 2,2-bis(4-aminophenyl)propane, 4,4'-diaminodiphenylsulfone and 4,4'-diaminodiphenyl ether. One species or two or more species thereof may be used. The content of the other diamine unit is 40 mol% or less, preferably 25 mol% or less, more preferably 10 mol% or less.

**[0056]** The relative viscosity of the (B) semi-aromatic polyamide as measured according to JIS K-6920 is preferably from 1.5 to 5.0, more preferably from 1.8 to 4.5, still more preferably from 2.0 to 4.0. If the relative viscosity is less than the above-described value, the obtained multilayer structure may have insufficient mechanical properties, whereas if it exceeds the above-described value, the extrusion pressure or torque becomes excessively high and this sometimes makes it difficult to produce a multilayer structure.

**[0057]** In the (B) semi-aromatic polyamide, the terminal of its molecular chain is preferably blocked by a terminal-blocking agent. The terminal-blocking agent preferably blocks 40% or more, more preferably 60% or more, of the terminal groups.

**[0058]** The terminal-blocking agent is not particularly limited as long as it is a monofunctional compound having reactivity with an amino or carboxyl group at the polyamide terminal. In view of reactivity, stability of the blocked terminal or the like, a monocarboxylic acid or a monoamine is preferred, and in view of easy handleability or the like, a monocarboxylic acid is more preferred. In addition, an acid anhydride, a monoisocyanate, a monoacid halide, a monoester, a monoalcohol and the like may also be used.

**[0059]** The monocarboxylic acid used as the terminal-blocking agent is not particularly limited as long as it has reactivity with an amino group, but examples thereof include an aliphatic monocarboxylic acid such as acetic acid, propionic acid, butyric acid, valeric acid, caproic acid, caprylic acid, lauric acid, tridecyl acid, myristic acid, palmitic acid, stearic acid, pivalic acid and isobutyric acid; an alicyclic monocarboxylic acid such as cyclohexanecarboxylic acid; and an aromatic monocarboxylic acid such as benzoic acid, toluic acid,  $\alpha$ -naphthalenecarboxylic acid,  $\beta$ -naphthalenecarboxylic acid, methylnaphthalenecarboxylic acid and phenylacetic acid. One species or two or more species thereof may be used. Among these, in view of reactivity, stability of the blocked terminal, cost and the like, an acetic acid, a propionic acid, a butyric acid, a valeric acid, a caproic acid, a caprylic acid, a lauric acid, a tridecyl acid, a myristic acid, a palmitic acid,



a stearic acid and a benzoic acid are preferred.

[0060] The monoamine used as the terminal-blocking agent is not particularly limited as long as it has reactivity with a carboxyl group, but examples thereof include an aliphatic monoamine such as methylamine, ethylamine, propylamine, butylamine, hexylamine, octylamine, decylamine, stearylamine, dimethylamine, diethylamine, dipropylamine and dibutylamine; an alicyclic monoamine such as cyclohexylamine and dicyclohexylamine; and an aromatic amine such as aniline, toluidine, diphenylamine and naphthylamine. One species or two or more species thereof may be used. Among these, in view of reactivity, boiling point, stability of the blocked terminal, cost and the like, butylamine, hexylamine, octylamine, decylamine, stearylamine, cyclohexylamine and aniline are preferred.

[0061] The amount of the terminal-blocking agent used at the production of the (B) semi-aromatic polyamide is determined by the relative viscosity of the finally obtained polyamide and the blocking percentage of the terminal group. Specifically, the terminal-blocking agent is usually used in an amount of 0.3 to 10 mol% based on the total molar number of dicarboxylic acid and diamine as raw materials, though this varies depending on the reactivity and boiling point of the terminal-blocking agent used, the reaction apparatus, the reaction conditions and the like.

[0062] The production apparatus for the (B) semi-aromatic polyamide includes a known polyamide production apparatus such as batch-system reactor, one-bath or multi-bath continuous reaction apparatus, tubular continuous reaction apparatus and kneading reaction extruder (e.g., single-screw kneading extruder, twin-screw kneading extruder). The polymerization may be performed by using a known polymerization method such as melt polymerization, solution polymerization or solid phase polymerization, and repeating the operation under atmospheric pressure, reduced pressure or applied pressure. These polymerization methods may be used individually or in an appropriate combination.

[0063] The (B) semi-aromatic polyamide may be a mixture with the above-described other polyamide-based resin or other thermoplastic resin or may be even a mixture with the (A) aliphatic polyamide for use in the present invention. The content of the (B) semi-aromatic polyamide in the mixture is preferably 80 wt% or more.

[0064] In the (B) semi-aromatic polyamide, a copper compound is preferably blended so as to enhance the long-term heat resistance. Examples of the copper compound include cuprous chloride, cupric chloride, cuprous bromide, cupric bromide, cuprous iodide, cupric iodide, cupric sulfate, cupric nitrate, cupric phosphate, cupric pyrophosphate, cuprous acetate, cupric acetate, cupric salicylate, cupric stearate, cupric benzoate, and a complex salt of the above-described inorganic copper halide with xylylenediamine, 2-mercaptobenzimidazole, 2-mercaptobenzothiazole, benzimidazole or the like. One species or two or more species thereof may be used.

[0065] The amount of the copper compound blended is preferably from 0.01 to 3 parts by weight, more preferably from 0.02 to 1 part by weight, per 100 parts by weight of the (B) semi-aromatic polyamide component. If the amount of the copper compound blended is less than 0.01 part by weight, the obtained multilayer structure may have poor heat resistance, whereas if it exceeds 3 parts by weight, release of a metal salt during melt forming of a multilayer structure occurs and the product value may be impaired due to coloring.

[0066] In the (B) semi-aromatic polyamide, an alkali metal halide compound may also be added in the form of combination use with the copper compound. Examples of the alkali metal halide compound include lithium chloride, lithium bromide, lithium iodide, lithium fluoride, sodium chloride, sodium bromide, sodium iodide, potassium chloride, potassium bromide, potassium iodide and potassium fluoride. One species or two or more species thereof may be used. Among these, potassium iodide is preferred. The amount of the alkali metal halide compound blended is preferably from 0.01 to 10 parts by weight, more preferably from 0.02 to 3 parts by weight, per 100 parts by weight of the (B) semi-aromatic polyamide compound, and at the same time, still more preferably from 100 to 1,000 parts by weight per 100 parts by weight of the copper compound.

[0067] For the purpose of enhancing the long-term heat resistance, the above-described copper compound and alkali metal halide compound are preferably blended also in the (A) aliphatic polyamide. In the case where the (A) aliphatic polyamide is a polyamide having a relatively small number of carbons per one amide group in the polyamide repeating unit, such as polyamide 6 or polyamide 66, the (B) semi-aromatic polyamide may be blended for the purpose of enhancing the calcium chloride resistance.

[0068] In the multilayer structure of the present invention, an electrically conducting filler is preferably blended in the (B) semi-aromatic polyamide disposed in the innermost layer so that, when the multilayer structure is used for piping hose or the like of various liquid chemicals, the liquid chemical can be prevented from catching fire as a result of accumulation of static electricity generated due to internal friction of the liquid chemical circulating in the pipe or due to friction against the pipe wall. By virtue of the electrically conducting filler, an explosion due to static electricity generated at the transportation of a fluid such as liquid chemical can be prevented. At this time, when a layer not having electrical conductivity is disposed on the outer side with respect to the electrically conducting layer, the low-temperature impact resistance and the electrical conductivity both can be attained and this is advantageous in view of profitability.

[0069] The electrically conducting filler includes all fillers added for imparting electrically conducting performance to a resin, and examples thereof include particulate, flaked or fibrous fillers.

[0070] Examples of the particulate filler include carbon black and graphite. Examples of the flaked filler which can be suitably used include aluminum flake, nickel flake and nickel-coated mica. Examples of the fibrous filler include carbon

fiber, carbon-coated ceramic fiber, carbon whisker, carbon nanotube and metal fiber such as aluminum fiber, copper fiber, brass fiber and stainless steel fiber. Among these, carbon nanotube and carbon black are preferred.

[0071] A carbon nanotube is a hollow carbon fibril. The hollow carbon fibril has an outside region comprising a large number of substantially continuous layers of regularly arranged carbon atoms, and an inside hollow region, and this is a substantially columnar fibril where respective layers and the hollow region are disposed substantially in a concentric manner around a cylindrical axis. Furthermore, it is preferred that the regularly arranged carbon atoms in the outside region are in the graphite state and the diameter of the hollow region is from 2 to 20 nm. The outer diameter of the carbon nanotube is preferably from 3.5 to 70 nm, more preferably from 4 to 60 nm. If the outer diameter is less than 3.5 nm, this may give rise to poor dispersibility into a resin, whereas if it exceeds 70 nm, the obtained resin form may have poor electrical conductivity. The aspect ratio (this means a ratio of length/outer diameter) of the carbon nanotube is preferably 5 or more, more preferably 100 or more, still more preferably 500 or more. By satisfying this aspect ratio, formation of an electrically conducting network is facilitated, and excellent electrical conductivity can be expressed by an addition of a small amount.

[0072] The carbon black includes all carbon blacks generally used for imparting electrical conductivity. Preferred examples of the carbon black include, but are not limited to, acetylene black obtained by the incomplete combustion of an acetylene gas, Ketjen black produced by the furnace-type incomplete combustion starting from crude oil, oil black, naphthalene black, thermal black, lamp black, channel black, roll black and disk black. Among these, acetylene black and furnace black (Ketjen black) are more preferred.

[0073] As for the carbon black, various carbon powders differing in the properties such as particle diameter, surface area, DBP absorption and ash content are being produced. The carbon black usable in the present invention is not particularly limited in these properties, but those having a good chain structure and a large aggregation density are preferred. In view of impact resistance, the carbon black is preferably not blended in a large amount. From the standpoint of obtaining excellent electrical conductivity with a smaller amount, the average particle diameter is preferably 500 nm or less, more preferably from 5 to 100 nm, still more preferably from 10 to 70 nm, the surface area (by BET method) is preferably 10 m<sup>2</sup>/g or more, more preferably 300 m<sup>2</sup>/g or more, still more preferably from 500 to 1,500 m<sup>2</sup>/g, the DBP (dibutyl phthalate) absorption is preferably 50 ml/100 g or more, more preferably 100 ml/100 g or more, still more preferably 300 ml/100 g or more, and the ash content is preferably 0.5 wt% or less, more preferably 0.3 wt% or less. The DBP absorption as used herein means a value measured by the method prescribed in ASTM D-2414. A carbon black having a volatile content of less than 1.0 wt% is more preferred.

[0074] The electrically conducting filler may be surface-treated with a surface-treating agent such as titanate type, aluminum type or silane type. In addition, a granulated electrically conducting filler may also be used so as to enhance the melt kneading workability.

[0075] The amount of the electrically conducting filler blended varies depending on the kind of the electrically conducting filler used and cannot be indiscriminately specified but, generally, and in view of balance of the electrical conductivity with flowability, mechanical strength and the like, the blending amount is preferably from 3 to 30 parts by weight per 100 parts by weight of the resin component.

[0076] Also, from the standpoint of obtaining a sufficiently high antistatic performance, the electrically conducting filler is preferably blended such that the melt-extruded product has a surface resistivity value of 10<sup>8</sup> Ω/square or less, more preferably 10<sup>6</sup> Ω/square or less. However, the blending of the electrically conducting filler is liable to incur lowering of strength and flowability and therefore, if the objective electrical conductivity level can be achieved, the amount of the electrically conducting filler blended is preferably as small as possible.

[0077] In the (B) semi-aromatic polyamide, an antioxidant, a heat stabilizer, an ultraviolet absorbent, a light stabilizer, a lubricant, an inorganic filler, an antistatic agent, a flame retardant, a crystallization accelerator, a plasticizer, a coloring agent, a lubricant agent, an impact resistance improver and the like may be further added, if desired. In order to improve the impact resistance of the (B) semi-aromatic polyamide, an impact resistance improver is preferably added. As for the impact resistance improver, a rubber-like polymer having a flexural modulus of 500 MPa or less as measured according to ASTM D-790, which is described for the (A) aliphatic polyamide, is more preferably added.

[0078] The multilayer structure of the present invention comprises at least a layer (a) comprising (A) an aliphatic polyamide and a layer (b) comprising (B) a semi-aromatic polyamide comprising a diamine unit containing an aliphatic diamine unit having a carbon number of 9 to 13 in an amount of 60 mol% or more based on all diamine units and a dicarboxylic acid unit containing a terephthalic acid and/or naphthalenedicarboxylic acid unit in an amount of 50 mol% or more based on all dicarboxylic acid units, and the layer (b) is disposed as the innermost layer. Fig. 1 is a cross-sectional view showing an example of such a multilayer structure. In Fig. 1, reference numeral 1 indicates a layer (a) as the outer layer, and 2 indicates a layer (b) as the inner layer.

[0079] In view of hot water resistance, liquid and/or gas chemical permeation-preventing property, chemical resistance and the like, a structure where the layer (b) comprising (B) a semi-aromatic polyamide is disposed as the innermost layer, is preferred and, in view of balance of physical properties of the hose including low-temperature impact resistance, a structure where the layer (a) comprising (A) an aliphatic polyamide is disposed as the outermost layer, is more preferred.

When use at high temperatures is taken into consideration, a structure comprising three or more layers, where the layer (b) comprising (B) a semi-aromatic polyamide is disposed as the innermost and outermost layers and the layer (a) comprising (A) an aliphatic polyamide is disposed as the intermediate layer, may also be employed. Fig. 2 is a cross-sectional view showing an example of the three-layer multilayer structure. In Fig. 2, reference numeral 5 indicates a layer (b) as the outer layer, 6 indicates a layer (b) as the inner layer, and 7 indicates a layer (a) as the intermediate layer.

[0080] In the multilayer structure of the present invention, it is essential to contain a layer (b) comprising (B) a semi-aromatic polyamide as the innermost layer. By virtue of disposing a layer (b) comprising (B) a semi-aromatic polyamide as the innermost layer, a multilayer structure excellent in the liquid and/or gas chemical permeation-preventing property and monomer-oligomer elution resistance can be obtained.

[0081] As for the monomer-oligomer elution resistance, the elution coefficient measured by the method described in Examples is preferably 0.1 g/m<sup>2</sup>·day or less, more preferably 0.05 g/m<sup>2</sup>·day or less.

[0082] In the multilayer structure of the present invention, the thickness of each layer is not limited and may be controlled according to the kind of the polymer constituting the layer, the total number of layers in the multilayer structure, or the like, but the thickness of each layer is determined by taking account of the properties of the multilayer structure, such as low-temperature impact resistance and flexibility. In general, the thickness of each of the layers (a) and (b) is preferably 3 to 100% based on the thickness of the entire multilayer structure. In view of the liquid and/or gas chemical permeation-preventing property, the thickness of the layer (b) is more preferably from 5 to 80%, still more preferably from 10 to 50%, based on the thickness of the entire multilayer structure.

[0083] The total number of layers in the multilayer structure of the present invention is not particularly limited and may be any number of layers as long as at least two layers including a layer (a) comprising (A) an aliphatic polyamide and a layer (b) comprising (B) a semi-aromatic polyamide are provided and the layer (b) is disposed as the innermost layer. In the multilayer structure of the present invention, one layer or two or more layers comprising other thermoplastic resin may be provided so as to impart an additional function or obtain a multilayer hose advantageous in view of profitability.

[0084] Examples of the other thermoplastic resin in the layer comprising other thermoplastic resin include a polyolefin-based resin such as high-density polyethylene (HDPE), medium-density polyethylene (MDPE), low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), ultrahigh molecular weight polyethylene (UHMWPE), polypropylene (PP), ethylene/propylene copolymer (EPR), ethylene/butene copolymer (EBR), ethylene/vinyl acetate copolymer (EVA), ethylene/vinyl acetate copolymer saponified product (EVOH), ethylene/acrylic acid copolymer (EAA), ethylene/methacrylic acid copolymer (EMAA), ethylene/methyl acrylate copolymer (EMA), ethylene/methyl methacrylate copolymer (EMMA) and ethylene/ethyl acrylate copolymer (EEA); a polyolefin-based resin obtained by modifying the above-described polyolefin-based resin with a compound or the like having a carboxyl group (e.g., acrylic acid, methacrylic acid, maleic acid, fumaric acid, itaconic acid, crotonic acid, mesaconic acid, citraconic acid, glutaconic acid, cis-4-cyclohexene-1,2-dicarboxylic acid, endo-bicyclo[2.2.1]-5-heptene-2,3-dicarboxylic acid) or its metal salt (Na, Zn, K, Ca, Mg), an acid anhydride group (e.g., malic anhydride, itaconic anhydride, citraconic anhydride, endo-bicyclo[2.2.1]-5-heptene-2,3-dicarboxylic anhydride), or an epoxy group (e.g., glycidyl acrylate, glycidyl methacrylate, glycidyl ethacrylate, glycidyl itaconate, glycidyl citraconate); a polyester-based resin such as polybutylene terephthalate (PBT), polyethylene terephthalate (PET), polyethylene isophthalate (PEI), PET/PEI copolymer, polyarylate (PAR), polybutylene naphthalate (PBN), polyethylene naphthalate (PEN) and liquid crystal polyester (LCP); a polyether-based resin such as polyacetal (POM) and polyphenylene oxide (PPO); a polysulfone-based resin such as polysulfone (PSF) and polyether sulfone (PES); a polythioether-based resin such as polyphenylene sulfide (PPS) and polythioethersulfone (PTES); a polyketone-based resin such as polyether ether ketone (PEEK) and polyallyl ether ketone (PAEK); a polynitrile-based resin such as polyacrylonitrile (PAN), polymethacrylonitrile, acrylonitrile/styrene copolymer (AS), methacrylonitrile/styrene copolymer, acrylonitrile/butadiene/styrene copolymer (ABS) and methacrylonitrile/styrene/butadiene copolymer (MBS); a polymethacrylate-based resin such as polymethyl methacrylate (PMMA) and polyethyl methacrylate (PEMA); a polyvinyl ester-based resin such as polyvinyl acetate (PVAc); a polyvinyl chloride-based resin such as polyvinylidene chloride (PVDC), polyvinyl chloride (PVC), vinyl chloride/vinylidene chloride copolymer and vinylidene chloride/methyl acrylate copolymer; a cellulose-based resin such as cellulose acetate and cellulose butyrate; fluorine-based resin such as polyvinylidene fluoride (PVDF), polyvinyl fluoride (PVF), ethylene/tetrafluoroethylene copolymer (ETFE), polychlorotrifluoroethylene (PCTFE), ethylene/chlorotrifluoroethylene copolymer (ECTFE), tetrafluoroethylene/hexafluoropropylene copolymer (TFE/HFP, FEP), tetrafluoroethylene/hexafluoropropylene/vinylidene fluoride copolymer (TFE/HFP/VDF, THV) and tetrafluoroethylene/fluoro(alkylvinylether) copolymer (PFA); a polycarbonate-based resin such as polycarbonate (PC); a polyimide-based resin such as thermoplastic polyimide (PI), polyamideimide (PAI) and polyether imide; a thermoplastic polyurethane-based resin; and a polyamide-based resin except for the (A) aliphatic polyamide and (B) semi-aromatic polyamide specified in the present invention, such as polymetaxylene adipamide (polyamide MXD6), polymetaxylene suberamide (polyamide MXD8), polymetaxylene azelamide (polyamide MXD9), polymetaxylene sebacamide (polyamide MXD10), polymetaxylene dodecamide (polyamide MXD12), polymetaxylene terephthalamide (polyamide MXDT), polymetaxylene isophthalamide (polyamide MXDI), polymetaxylene naphthalamide (polyamide MXDN), polybis(4-aminocyclohexyl)methane dodecamide (polyamide PACM12), polybis(4-aminocyclohexyl)methane terephthala-

mide (polyamide PACMT), polybis(4-aminocyclohexyl)methane isophthalamide (polyamide PACMI), polybis(3-methyl-4-aminocyclohexyl)methane dodecamide (polyamidedimethyl PACM12), polyisophorone adipamide (polyamide IPD6), polyisophorone terephthalamide (polyamide IPDT), polyhexamethylene terephthalamide (polyamide 6T), polyhexamethylene isophthalamide (polyamide 6I), polynonamethylene isophthalamide (polyamide 9I), polynonamethylene hexahydroterephthalamide (polyamide 9T(H)), polydecamethylene isophthalamide (polyamide 10I), polydecamethylene hexahydroterephthalamide (polyamide 10T(H)), polyundecamethylene isophthalamide (polyamide 11I), polyundecamethylene hexahydroterephthalamide (polyamide 11T(H)), polydodecamethylene isophthalamide (polyamide 12I), polydodecamethylene hexahydroterephthalamide (polyamide 12T(H)), and a copolymer using a plurality of species of raw material monomers of these polyamides. Among these, a polyolefin-based resin, a polyester-based resin, a polyamide-based resin, a polythioether-based resin and a fluorine-based resin are preferred, a polyolefin-based resin, a polyester-based resin, a polyamide-based resin and a fluorine-based resin are more preferred, and a polyamide-based resin and a fluorine-based resin are still more preferred.

**[0085]** Furthermore, an arbitrary base material other than the thermoplastic resin, such as paper, metal-based material, unstretched or uniaxially or biaxially stretched plastic film or sheet, woven fabric, non-woven fabric, metal cotton and wood material, may also be laminated. Examples of the metal-based material include a metal or metal compound such as aluminum, iron, copper, nickel, gold, silver, titanium, molybdenum, magnesium, manganese, lead, tin, chromium, beryllium, tungsten and cobalt, and alloys comprising two or more species thereof, such as an alloy steel (e.g., stainless steel), an aluminum alloy, a copper alloy (e.g., brass, bronze) and a nickel alloy.

**[0086]** The number of layers in the multilayer structure of the present invention is 2 or more, but in view of mechanism of the multilayer structure producing apparatus, the number of layers is preferably 7 or less, more preferably from 2 to 5, still more preferably from 2 to 4. Also, in the multilayer structure of the present invention, from the standpoint of enhancing the interlayer adhesion, the layer (a) and the layer (b) are preferably adjacent to each other.

**[0087]** Examples of the method for producing the multilayer structure of the present invention include a method of melt-extruding the materials by using extruders corresponding to the number of layers or the number of materials and simultaneously laminating the layers in the inside or outside of a die (coextrusion method), and a method of once producing a single-layer tube or previously producing a multilayer structure by the above-described method and then sequentially integrating and laminating the resins on the outer side by using, if desired, an adhesive (coating method). The multilayer structure of the present invention is preferably produced by a coextrusion method where (A) an aliphatic polyamide for forming the outer layer and (B) a semi-aromatic polyamide for forming the inner layer are coextrusion-shaped in the melted state and both are heat-fused (melt-bonded) to produce a hose having a multilayer structure in one step.

**[0088]** In the case where the obtained multilayer structure has a complicated shape or is formed into a shaped article by applying heat bending after the shaping, the objective shaped article may also be obtained by heat-treating the formed multilayer structure at a temperature less than the lowest melting point among melting points of the resins constituting the multilayer structure for 0.01 to 10 hours so as to remove the residual strain in the shaped article.

**[0089]** The multilayer structure of the present invention may have an undulating region. The undulating region means a region formed into a shape of wave, bellows, accordion, corrugation or the like. The undulating region may be provided over the entire length of the multilayer structure or may be partially provided in an appropriate middle portion. The undulated region can be easily formed by shaping a straight tube and subsequently mold-shaping it to have a predetermined undulated form or the like. By virtue of having such an undulated region, an impact-absorbing property is imparted and the fixing operation is facilitated. Furthermore, for example, necessary parts may be attached or formation into L-shape or U-shape may be attained by bending.

**[0090]** By taking account of pebbling, abrasion with other parts and flame resistance, the outer circumference of the thus-shaped multilayer structure may be entirely or partially provided with a solid or sponge-like protective member (protector) formed of epichlorohydrin rubber (ECO), acrylonitrile/butadiene rubber (NBR), an NBR and polyvinyl chloride mixture, chlorosulfonated polyethylene rubber, chlorinated polyethylene rubber, acrylic rubber (ACM), chloroprene rubber (CR), ethylene/propylene rubber (EPR), ethylene/propylene/diene rubber (EPDM), an NBR and EPDM mixture rubber, or a thermoplastic elastomer such as vinyl chloride type, olefin type, ester type and amide type. The protective member may be formed as a sponge-like porous material by a known method. By forming a porous material, a lightweight and highly adiabatic protective part can be provided. Also, the material cost can be reduced. Alternatively, the strength of the protective member may be improved by adding glass fiber or the like. The shape of the protective member is not particularly limited, but a cylindrical member or a block member having a recess for receiving the multilayer hose is usually used. In the case of a cylindrical member, the multilayer hose is inserted into a previously prepared cylindrical member, or a cylindrical member is coated by extrusion on the multilayer hose, thereby tightly contacting the cylindrical member and the multilayer hose. For bonding these two members, an adhesive is coated, if desired, on the inner surface or recess surface of the protective member and the multilayer hose is inserted or fitted therein to tightly contact these two members with each other, thereby forming a structure where the multilayer hose and the protective member are integrated. Also, reinforcement by a metal or the like may be applied.

[0091] The outer diameter of the multilayer structure is not limited but in view of flow rate of the circulating liquid and/or gas chemical (for example, engine cooling liquid) or the like, the wall thickness is designed to a thickness allowing for no increase in the liquid and/or gas chemical permeability, capable of maintaining the burst pressure in a level of a normal tube, and capable of maintaining flexibility to such an extent that the hose can be easily fixed and good vibration resistance is ensured on use. Preferably, the outer diameter is from 4 to 200 mm, the inner diameter is from 2 to 160 mm, and the wall thickness is from 0.5 to 20 mm.

[0092] The multilayer structure of the present invention is excellent in liquid and/or gas chemical permeation-preventing properties at high temperatures and in heat resistance and therefore, is useful as a hose for transporting a high-temperature liquid and/or gas chemical. In the present invention, the high-temperature liquid and/or gas chemical means that a liquid and/or gas chemical is at 60°C or more, and indicates a liquid and/or gas chemical momentarily or continuously flowing or circulating in the multilayer hose at such a temperature.

[0093] Examples of the liquid chemical include an aromatic hydrocarbon-based solvent such as benzene, toluene and xylene, an alcohol- or phenol-based solvent such as methanol, ethanol, propanol, butanol, pentanol, ethylene glycol, propylene glycol, diethylene glycol, phenol, cresol, polyethylene glycol and polypropylene glycol, an ether-based solvent such as dimethyl ether, dipropyl ether, methyl-tert-butyl ether, dioxane and tetrahydrofuran, a halogen-based solvent such as chloroform, methylene chloride, trichloroethylene, ethylene dichloride, perchloroethylene, monochloroethane, dichloroethane, tetrachloroethane, perchloroethane and chlorobenzene, a ketone-based solvent such as acetone, methyl ethyl ketone, diethyl ketone and acetophenone, a urea solution, gasoline, kerosine, diesel gasoline, alcohol-containing gasoline, oxygen-containing gasoline, amine-containing gasoline, sour gasoline, castor oil-based brake fluid, glycol ether-type brake fluid, boric acid ester-type brake fluid, brake fluid for very cold regions, silicone oil-type brake fluid, mineral oil-type brake fluid, power steering oil, hydrogen sulfide-containing oil, engine cooling liquid, window washer liquid, medicine, ink and coating material. In the present invention, an aqueous solution containing such a liquid chemical as a component is also included in the liquid chemical of the present invention.

[0094] Examples of the gas include Freon-11, Freon-12, Freon-21, Freon-22, Freon-113, Freon-114, Freon-115, Freon-134A, Freon-32, Freon-123, Freon-124, Freon-125, Freon-143A, Freon-141b, Freon-142-b, Freon-225, Freon-C318, Freon-502, methyl chloride, ethyl chloride, air, oxygen, hydrogen, nitrogen, carbon dioxide, methane, propane, isobutane, n-butane, argon, helium and xenon.

## EXAMPLES

[0095] The present invention is described in greater detail below by referring to Examples and Comparative Examples, but the present invention is not limited thereto.

[0096] In Examples and Comparative Examples, the analysis and measurement of physical properties were performed as follows.

### [Relative Viscosity]

[0097] The relative viscosity was measured according to JIS K-6920 in 96% sulfuric acid under the conditions of a polyamide concentration of 1% and a temperature of 25°C.

### [Evaluation of Physical Properties]

#### (Low-Temperature Impact Resistance)

[0098] This was evaluated by the method described in SAE J-2260.

#### (Alcohol-Containing Gasoline Permeation-Preventing Property)

[0099] One end of a tube cut to 200 mm was plugged, alcohol-containing gasoline obtained by mixing Fuel C (isooctane/toluene = 50/50 by volume) and ethanol at a volume ratio of 90/10 was charged into the inside, and the other end was also plugged. Thereafter, the weight of the entirety was measured, then the test tube was placed in an oven at 60°C, and the change in weight was measured every day. The fuel permeation coefficient (g/m<sup>2</sup>-day) was calculated by dividing the change in weight per day by the inner layer surface area of the tube.

#### (Interlayer Adhesion)

[0100] A hose cut to 200 mm was further cut in half in the longitudinal direction to prepare a test piece. The test piece was subjected to a 180° peel test at a pulling speed of 50 mm/min by using a Tensilon universal tester. The peel strength

was read from the peak of the S-S curve and the interlayer adhesion was evaluated.

(Alcohol-Containing Gasoline Elution-Preventing Property)

**[0101]** One end of a tube cut to 1 m was plugged, alcohol-containing gasoline obtained by mixing Fuel C (isooctane/toluene=50/50 by volume) and ethanol at a volume ratio of 90/10 was charged into the inside, and the other end was also plugged. Thereafter, the test tube was placed in an oven at 60°C and heated for 7 days. After the completion of treatment, the alcohol-containing gasoline in the tube taken out was filtered through a filter having a passing particle diameter of 8 µm, and the weight of the collected matter was measured. The elution coefficient (g/m<sup>2</sup>·day) was calculated by dividing the weight of the collected matter by the treatment days and inner layer surface area of the tube.

**[0102]** After the completion of treatment, the color tone of the alcohol-containing gasoline extracted from the tube was also observed by eye.

[Materials Used in Examples and Comparative Examples]

(A) Aliphatic Polyamide

(A-1) Production of Polyamide 12 Resin Composition

**[0103]** A maleic anhydride-modified ethylene/propylene copolymer (JSR T7712SP, produced by JSR Corporation) as an impact resistance improver was previously mixed with polyamide 12 (UBESTA3030U, produced by Ube Industries, Ltd., relative viscosity: 2.27). While supplying the mixture to a twin-screw melt-kneading machine (manufactured by Japan Steel Works, Ltd., model: TEX44), benzenesulfonic acid butylamide as a plasticizer was fed by a quantitative pump in the middle of the cylinder of the twin-screw melt-kneading machine and melt-kneaded at a cylinder temperature of 180 to 260°C. The resulting resin melt was extruded as a strand, introduced into a water tank, cooled, cut and then vacuum-dried to obtain pellets of a polyamide 12 resin composition comprising 85 wt% of polyamide 12 resin, 10 wt% of impact resistance improver and 5 wt% of plasticizer (hereinafter, this polyamide resin composition is referred to as (A-1)).

(A-2) Production of Polyamide 12 Resin Composition

**[0104]** Pellets of a polyamide 12 resin composition comprising 90 wt% of polyamide 12 resin and 10 wt% of impact resistance improver were obtained in the same manner as in the production method of (A-1) above except for not using a plasticizer (hereinafter, this polyamide resin composition is referred to as (A-2)).

(A-3) Production of Polyamide 66 Resin Composition

**[0105]** A maleic anhydride-modified ethylene/propylene copolymer (JSR T7712SP, produced by JSR Corporation) as an impact resistance improver and a hexamethylene terephthalamide/hexamethylene isophthalamide copolymer (polyamide 6T/6I) (Grivory G21, produced by EMS-Showa Denko K.K.) as a calcium chloride resistance improver were previously mixed with polyamide 66 (UBE Nylon 2026B, produced by Ube Industries, Ltd., relative viscosity: 3.36), and the mixture was supplied to a twin-screw melt-kneading machine (manufactured by Japan Steel Works, Ltd., model: TEX44) and melt-kneaded at a cylinder temperature of 200 to 290°C. The resulting resin melt was extruded as a strand, introduced into a water tank, cooled, cut and then vacuum-dried to obtain pellets of a polyamide 66 resin composition comprising 65 wt% of polyamide 66 resin, 15 wt% of impact resistance improver and 20 wt% of calcium chloride resistance improver (hereinafter, this polyamide resin composition is referred to as (A-3)).

(A-4) Production of Polyamide 6 Resin Composition

**[0106]** Pellets of a polyamide 6 resin composition comprising 65 wt% of polyamide 6 resin, 15 wt% of impact resistance improver and 20 wt% of calcium chloride resistance improver were obtained in the same manner as in the production of (A-3) Polyamide 66 Resin Composition except for changing the polyamide 66 (UBE Nylon 2026B, produced by Ube Industries, Ltd., relative viscosity: 3.36) to polyamide 6 (UBE Nylon 1030B, produced by Ube Industries, Ltd., relative viscosity: 4.08) and melt-kneading the mixture at a cylinder temperature of 200 to 260°C (hereinafter, this polyamide resin composition is referred to as (A-4)).

## (B) Semi-Aromatic Polyamide

## (B-1) Production of Polyamide 9T

5 [0107] Into an autoclave, 32,927 g (198.2 mol) of terephthalic acid, 26,909 g (170 mol) of 1,9-nonanediamine, 4748.7 g (30 mol) of 2-methyl-1,8-octanediamine, 439.6 g (3.6 mol) of benzoic acid, 60 g of sodium hypophosphite monohydrate (0.1 wt% based on raw material) and 40 liter of distilled water were charged. Then, the system was purged with nitrogen.

10 [0108] The contents were stirred at 100°C for 30 minutes and the internal temperature was elevated to 210°C over 2 hours. At this time, the pressure in the autoclave was increased to 2.2 MPa. After continuing the reaction in this state for 1 hour, the temperature was elevated to 230°C, and the temperature was then kept at 230°C for 2 hours to allow the reaction to proceed while keeping the pressure at 2.2 MPa by gradually extracting the water vapor. Subsequently, the pressure was reduced to 1.0 MPa over 30 minutes, and the reaction was further allowed to proceed for 1 hour to obtain a prepolymer. This prepolymer was dried at 100°C for 12 hours under reduced pressure, ground to a size of 2 mm or less and then subjected to solid phase polymerization at 230°C under 0.013 kPa for 10 hours to obtain a polyamide 9T  
15 having a melting point of 306°C and a relative viscosity of 2.78 (hereinafter this polyamide resin is referred to as (B-1)).

## (B-2) Production of Polyamide 9T

20 [0109] A polyamide 9T having a melting point of 265°C and a relative viscosity of 2.80 was obtained in the same manner as in the method of (B-1) Production of Polyamide 9T except that in (B-1) Production of Polyamide 9T, 26,909 g (170 mol) of 1,9-nonanediamine was changed to 15,829 g (100 mol) and 4,748.7 g (30 mol) of 2-methyl-1,8-octanediamine was changed to 15,829 g (100 mol) (hereinafter this polyamide resin is referred to as (B-2)).

## (B-3) Production of Polyamide 9T Resin Composition

25 [0110] JSR T7712SP (produced by JSR Corporation) as an impact resistance improver was previously mixed with the polyamide 9T obtained in (B-2) above, and the mixture was supplied to a twin-screw melt-kneading machine (manufactured by Japan Steel Works, Ltd., model: TEX44) and melt-kneaded at a cylinder temperature of 265 to 300°C. The resulting resin melt was extruded as a strand, introduced into a water tank, cooled, cut and then vacuum-dried to obtain  
30 pellets of a polyamide 9T resin composition comprising 90 wt% of polyamide 9T resin and 10 wt% of impact resistance improver (hereinafter, this polyamide resin composition is referred to as (B-3)).

## (B-4) Production of Polyamide 9N

35 [0111] Into an autoclave, 42,848 g (198.2 mol) of 2,6-naphthalenedicarboxylic acid, 26,909 g (170 mol) of 1,9-nonanediamine, 4748.7 g (30 mol) of 2-methyl-1,8-octanediamine, 439.6 g (3.6 mol) of benzoic acid, 60 g of sodium hypophosphite monohydrate (0.1 wt% based on raw material) and 40 L of distilled water were charged. Then, the system was purged with nitrogen.

40 [0112] The contents were stirred at 100°C for 30 minutes and the internal temperature was elevated to 210°C over 2 hours. At this time, the pressure in the autoclave was increased to 2.2 MPa. After continuing the reaction in this state for 1 hour, the temperature was elevated to 230°C, and the temperature was then kept at 230°C for 2 hours to allow the reaction to proceed while keeping the pressure at 2.2 MPa by gradually extracting the water vapor. Subsequently, the pressure was reduced to 1.0 MPa over 30 minutes, and the reaction was further allowed to proceed for 1 hour to obtain a prepolymer. This prepolymer was dried at 100°C for 12 hours under reduced pressure, ground to a size of 2 mm or  
45 less and then subjected to solid phase polymerization at 230°C under 0.013 kPa for 10 hours to obtain a polyamide 9N having a melting point of 303°C and a relative viscosity of 2.32 (hereinafter this polyamide resin is referred to as (B-4)).

## (B-5) Production of Polyamide 9N

50 [0113] A polyamide 9N having a melting point of 275°C and a relative viscosity of 2.40 was obtained in the same manner as in the method of (B-4) Production of Polyamide 9N except that in (B-4) Production of Polyamide 9N, 26,909 g (170 mol) of 1,9-nonanediamine was changed to 15,829 g (100 mol) and 4,748.7 g (30 mol) of 2-methyl-1,8-octanediamine was changed to 15,829 g (100 mol) (hereinafter this polyamide resin is referred to as (B-5)).

## (B-6) Production of Polyamide 9N Resin Composition

55 [0114] JSR T7712SP (produced by JSR Corporation) as an impact resistance improver was previously mixed with the polyamide 9N obtained in (B-5) above, and the mixture was supplied to a twin-screw melt-kneading machine (man-



ufactured by Japan Steel Works, Ltd., model: TEX44) and melt-kneaded at a cylinder temperature of 275 to 310°C. The resulting resin melt was extruded as a strand, introduced into a water tank, cooled, cut and then vacuum-dried to obtain pellets of a polyamide 9N resin composition comprising 90 wt% of polyamide 9N resin and 10 wt% of impact resistance improver (hereinafter, this polyamide resin composition is referred to as (B-6)).

Example 1:

[0115] The above-described (A) polyamide 12 resin composition (A-1) and (B) polyamide 9T (B-1) were separately melted by using a two-layer tube forming machine (manufactured by Plabor Co., Ltd.) at an extrusion temperature of 250°C for (A) and an extrusion temperature of 330°C for (B), and the discharged resin melts were joined by means of an adapter and shaped into a multilayer tubular form. Subsequently, the shaped article was cooled by a sizing die capable of controlling the dimension and was withdrawn to obtain a multilayer tube having an inner diameter of 6 mm and an outer diameter of 8 mm and having a layer structure of (a)/(b)=0.75/0.25 mm consisting of a layer (a) comprising (A) a polyamide 12 resin composition (outer layer) and a layer (b) comprising (B) a polyamide 9T (inner layer). The physical properties of this multilayer tube were measured and the results obtained are shown in Table 1.

Example 2:

[0116] A multilayer tube having a layer structure shown in Table 1 was obtained in the same manner as in Example 1 except that in Example 1, the (B) polyamide 9T (B-1) was changed to polyamide 9T (B-2) and the resins were separately melted at an extrusion temperature of 300°C for (B). The physical properties of this multilayer tube were measured and the results obtained are shown in Table 1.

Example 3:

[0117] A multilayer tube having a layer structure shown in Table 1 was obtained in the same manner as in Example 2 except that in Example 2, the (A) polyamide 12 resin composition (A-1) was changed to polyamide 12 resin composition (A-2). The physical properties of this multilayer tube were measured and the results obtained are shown in Table 1.

Example 4:

[0118] A multilayer tube having a layer structure shown in Table 1 was obtained in the same manner as in Example 1 except that in Example 1, the (B) polyamide 9T (B-1) was changed to polyamide 9T resin composition (B-3) and the resins were separately melted at an extrusion temperature of 300°C for (B). The physical properties of this multilayer tube were measured and the results obtained are shown in Table 1.

Example 5:

[0119] A multilayer tube having a layer structure shown in Table 1 was obtained in the same manner as in Example 1 except that in Example 2, the (A) polyamide 12 resin composition (A-1) was changed to polyamide 66 resin composition (A-3) and the resins were separately melted at an extrusion temperature of 280°C for (A). The physical properties of this multilayer tube were measured and the results obtained are shown in Table 1.

Example 6:

[0120] A multilayer tube having a layer structure shown in Table 1 was obtained in the same manner as in Example 1 except that in Example 2, the (A) polyamide 12 resin composition (A-1) was changed to polyamide 6 resin composition (A-4) and the resins were separately melted at an extrusion temperature of 260°C for (A). The physical properties of this multilayer tube were measured and the results obtained are shown in Table 1.

Example 7:

[0121] A multilayer tube having a layer structure shown in Table 1 was obtained in the same manner as in Example 1 except that in Example 1, the (B) polyamide 9T (B-1) was changed to polyamide 9N (B-4). The physical properties of this multilayer tube were measured and the results obtained are shown in Table 1.

## Example 8:

[0122] A multilayer tube having a layer structure shown in Table 1 was obtained in the same manner as in Example 1 except that in Example 1, the (B) polyamide 9T (B-1) was changed to polyamide 9N (B-5) and the resins were separately melted at an extrusion temperature 300°C for (B). The physical properties of this multilayer tube were measured and the results obtained are shown in Table 1.

## Example 9:

[0123] A multilayer tube having a layer structure shown in Table 1 was obtained in the same manner as in Example 8 except that in Example 8, the (A) polyamide 12 resin composition (A-1) was changed to polyamide 12 resin composition (A-2). The physical properties of this multilayer tube were measured and the results obtained are shown in Table 1.

## Example 10:

[0124] A multilayer tube having a layer structure shown in Table 1 was obtained in the same manner as in Example 1 except that in Example 1, the (B) polyamide 9T (B-1) was changed to polyamide 9N resin composition (B-6) and the resins were separately melted at an extrusion temperature of 300°C for (B). The physical properties of this multilayer tube were measured and the results obtained are shown in Table 1.

## Comparative Example 1:

[0125] The above-described (A) polyamide 12 resin composition (A-1) and (B) polyamide 9T (B-2) were separately melted by using a three-layer tube forming machine (manufactured by Plabor Co., Ltd.) at an extrusion temperature of 260°C for (A) and an extrusion temperature of 300°C for (B), and the discharged resin melts were joined by means of an adapter and shaped into a multilayer structure. Subsequently, the shaped article was cooled by a sizing die capable of controlling the dimension and was withdrawn to obtain a multilayer tube having an inner diameter of 6 mm and an outer diameter of 8 mm and having a layer structure of (a)/(b)/(c)=0.40/0.25/0.35 mm consisting of a layer (a) comprising (A) a polyamide 12 resin composition (outermost layer), a layer (b) comprising (B) a polyamide 9T (intermediate layer), and a layer (c) comprising (C) a polyamide 12 resin composition (innermost layer). The physical properties of this multilayer tube were measured and the results obtained are shown in Table 1.

## Comparative Example 2:

[0126] A multilayer tube having a layer structure shown in Table 1 was obtained in the same manner as in Comparative Example 1 except that in Comparative Example 1, the (B) polyamide 9T (B-2) was changed to polyamide 9N (B-5). The physical properties of this multilayer tube were measured and the results obtained are shown in Table 1.

Table 1

	Outermost Layer		Intermediate Layer		Innermost Layer		Low-Temperature Impact Resistance (number of ruptured tubes/ number of tested tubes)	Fuel Permeation Coefficient (g/m <sup>2</sup> ·day)	Peel Strength (N/cm)	Elution Coefficient (g/m <sup>2</sup> ·day)	Color/Tone of Fuel after Treatment (visual)
	Kind	Thickness [mm]	Kind	Thickness [mm]	Kind	Thickness [mm]					
Example 1	A-1	0.75	-	-	B-1	0.25	0/10	2.3	43	0.03	clear
Example 2	A-1	0.75	-	-	B-2	0.25	0/10	3.0	45	0.03	clear
Example 3	A-2	0.75	-	-	B-2	0.25	0/10	3.0	46	0.03	clear
Example 4	A-1	0.75	-	-	B-3	0.25	0/10	2.5	42	0.03	clear
Example 5	A-3	0.75	-	-	B-2	0.25	0/10	3.0	42	0.03	clear
Example 6	A-4	0.75	-	-	B-2	0.25	0/10	3.0	46	0.03	clear
Example 7	A-1	0.75	-	-	B-4	0.25	0/10	1.5	39	0.01	clear
Example 8	A-1	0.75	-	-	B-5	0.25	0/10	2.0	43	0.01	clear
Example 9	A-2	0.75	-	-	B-5	0.25	0/10	2.0	44	0.01	clear
Example 10	A-1	0.75	-	-	B-6	0.25	0/10	1.8	41	0.01	clear
Comparative Example 1	A-1	0.40	B-2	0.25	A-1	0.35	0/10	3.0	48	0.2	white turbid
Comparative Example 2	A-1	0.40	B-5	0.25	A-1	0.35	0/10	2.0	46	0.2	white turbid

## INDUSTRIAL APPLICABILITY

[0127] A multilayer shaped article comprising the multilayer structure of the present invention can be utilized in automobile parts, industrial materials, industrial supplies, electrical and electronic parts, machine parts, office equipment parts, household articles, containers, sheets, films, fibers and other various shaped articles having arbitrary usage and shape. More specifically, the shaped article includes tubes or hoses such as automotive fuel piping tubes or hoses, automotive radiator hoses, brake hoses, air conditioner hoses, wire coating material and optical fiber coating material; films or sheets such as agricultural film, lining, building interior material (e.g., wallpaper) and laminated steel sheet; and tanks such as automotive radiator tanks, liquid chemical bottles, liquid chemical tanks, bags, liquid chemical containers and gasoline tanks. In particular, the multilayer structure is useful in automotive fuel piping tubes or hoses.

## Claims

1. A multilayer structure comprising two or more layers including at least a layer (a) comprising (A) an aliphatic polyamide and a layer (b) comprising (B) a semi-aromatic polyamide comprising a diamine unit containing an aliphatic diamine unit having a carbon number of 9 to 13 in an amount of 60 mol% or more based on all diamine units and a dicarboxylic acid unit containing a terephthalic acid and/or naphthalenedicarboxylic acid unit in an amount of 50 mol% or more based on all dicarboxylic acid units, with said layer (b) being disposed as the innermost layer.
2. The multilayer structure as claimed in claim 1, wherein said multilayer structure comprises a two-layer construction of (a)/(b).
3. The multilayer structure as claimed in claim 1 or 2, wherein the (A) aliphatic polyamide is at least one homopolymer selected from the group consisting of polycaproamide (polyamide 6), polyhexamethylenedipamide (polyamide 66), polyhexamethylenedodecamide (polyamide 612), polyundecanamide (polyamide 11) and polydodecanamide (polyamide 12), or a copolymer using a plurality of species of raw material monomers forming these polyamides.
4. The multilayer structure as claimed in any one of claims 1 to 3, wherein the (B) semi-aromatic polyamide is a polyamide comprising a diamine unit containing a 1,9-nonanediamine and/or 2-methyl-1,8-octanediamine unit in an amount of 60 mol% or more based on all diamine units and a dicarboxylic acid unit containing a terephthalic acid unit in an amount of 50 mol% or more based on all dicarboxylic acid units.
5. The multilayer structure as claimed in any one of claims 1 to 3, wherein the (B) semi-aromatic polyamide is a polyamide comprising a diamine unit containing a 1,9-nonanediamine and/or 2-methyl-1,8-octanediamine unit in an amount of 60 mol% or more based on all diamine units and a dicarboxylic acid unit containing a naphthalenedicarboxylic acid unit in an amount of 50 mol% or more based on all dicarboxylic acid units.
6. The multilayer structure as claimed in any one of claims 1 to 5, wherein said layer (b) has electrical conductivity.
7. The multilayer structure as claimed in any one of claims 1 to 6, wherein the layers are formed by coextrusion.
8. A multilayer structure selected from the group consisting of a film, a hose, a tube, a bottle and a tank, comprising the multilayer structure claimed in any one of claims 1 to 7.
9. The multilayer structure as claimed in claim 8, which is an automotive fuel piping tube or a hose.
10. The multilayer structure as claimed in any one of claims 1 to 9, wherein the layer (a) and the layer (b) are adjacently disposed.

Fig. 1

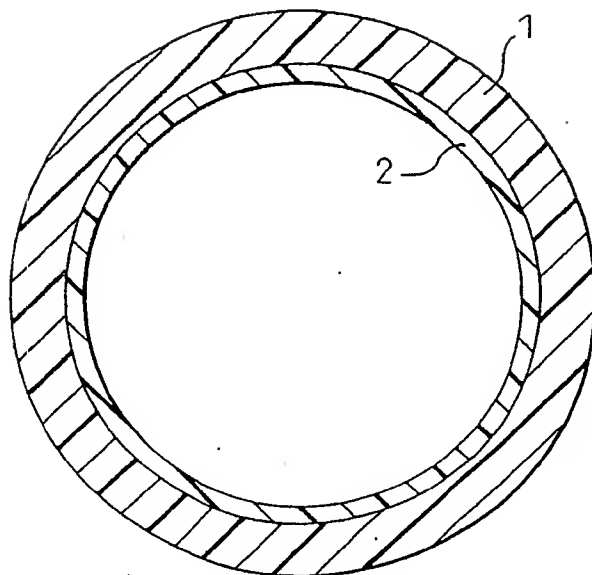
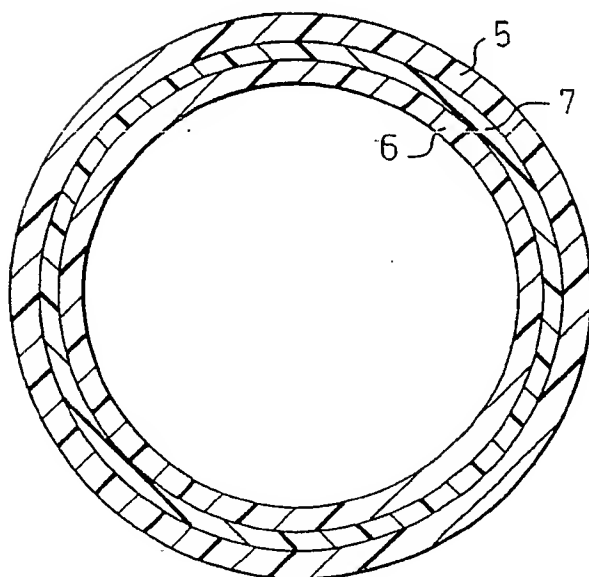


Fig. 2



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/008380

A. CLASSIFICATION OF SUBJECT MATTER Int. Cl. <sup>7</sup> B32B27/34, 1/08, B65D1/09, F16L11/04		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int. Cl. <sup>7</sup> B32B1/00-35/00, B65D1/09, F16L9/00-11/18		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2005 Kokai Jitsuyo Shinan Koho 1971-2005 Toroku Jitsuyo Shinan Koho 1994-2005		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E, X	JP 2005-119017 A (Ube Industries, Ltd.), 12 May, 2005 (12.05.05), (Family: none)	1-10
E, X	JP 2005-178076 A (Ube Industries, Ltd.), 07 July, 2005 (07.07.05), (Family: none)	1-10
P, A	JP 2004-244579 A (Ube Industries, Ltd.), 02 September, 2004 (02.09.04), (Family: none)	1-10
A	JP 2003-247672 A (EMS-Chemie AG.), 05 September, 2003 (05.09.03), & US 2003/190444 A1 & EP 1333052 A1	1-10
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 03 August, 2005 (03.08.05)		Date of mailing of the international search report 16 August, 2005 (16.08.05)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/008380

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 3-7761 A (Mitsui Petrochemical Industries, Ltd.), 14 January, 1991 (14.01.91), (Family: none)	1-10

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